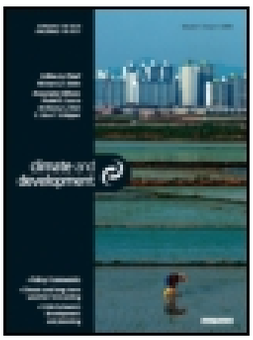

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RESEARCH ARTICLE

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Women's vulnerability to climate-related risks to household water security in Centre-East, Burkina Faso

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ABSTRACT

Variable climate conditions, resulting in periods of water scarcity and longer dry spells, or intense rainfall events, have serious implications for water and sanitation services. Climate change threatens to exacerbate these hazards, increasing risks to household water security, and associated impacts on health, wellbeing and livelihoods. These risks are not evenly distributed across individuals and communities, and there is a particular need to understand women's vulnerabilities and responses to these risks due to disproportionate impacts of poor water and sanitation conditions. This study used mixed-methods data collection to assess how vulnerabilities to climate-related risks to household water security are produced and vary among women in the Centre-East region, Burkina Faso, as well as capacities to respond. Gendered water-related roles and norms were found to drive vulnerabilities for women in the case study site particularly related to increasingly inadequate water availability during the dry season. Other social differences such as Mossi and Peul ethnicity which influence ways of using water, also contributed to women's differential vulnerability and capacities to respond. These findings show there is a need to consider how the development of 'climate resilient' water and sanitation services take social drivers of vulnerability into account.

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Drinking water; sanitation; gender; West Africa; adaptation; vulnerability

1. Introduction

In recognition of the critical role water plays for human development and wellbeing, the Sustainable Development Goals (SDGs) include a dedicated goal to achieve clean water and sanitation. This includes targets 6.1 and 6.2 for improving access to drinking water, and to sanitation and hygiene services (WASH) respectively, as well as other water-related targets on efficiency, water quality and integrated water resources management at all levels. The SDG Agenda is underpinned with the message to 'leave no one behind' that addresses critiques of the Millennium Development Goals that an aggregate approach exacerbated or failed to address inequalities between different groups (Cobham, 2014; UNICEF, 2015). SDG targets 6.1 and 6.2 include both higher levels of water and sanitation services, as well as language on 'universal access' to ensure the needs of marginalized groups are met. A greater focus on inequalities in the WASH sector has enabled identification of broad trends, such as lower levels of services in many rural areas and among poorer people (WHO/UNICEF JMP, 2019). However little sex-disaggregated data will be collected to track these targets, limiting analysis of factors contributing to gender inequalities.

Climate change is an increasingly important factor that will influence progress to meet these water and sanitation targets, with particular consequences for marginalized groups (Howard et al., 2016). Climate change is expected to impact the water cycle through greater climatic and hydrological variability, threatening household water security that plays a critical role in promoting human health and wellbeing (Bartram & Cairncross, 2010; Bates et al., 2008; Niang et al., 2014). Increased variability of precipitation and water flows, and more frequent extreme events such as droughts and floods, will impact drinking water, sanitation, and hygiene services (Hadwen et al., 2015). In water-stressed regions, this can place additional stress on water supplies leading to poorer water quality. Water scarcity may also force people to travel greater distances to access water, which can result in deteriorated sanitation and hygiene conditions, such as limited water for hand-washing (Howard et al., 2016). In areas prone to flooding hazards, damage to water and sanitation infrastructure, such as pit toilets, may contaminate the surrounding environment and drinking water supplies. In addition, warming temperatures are expected to increase diarrhea associated with poor water and sanitation (Mellor et al., 2016). Other important drivers of change may interact, and further exacerbate these climate-related hazards, such as migration to areas with limited services and growing competition for water for productive purposes (Nielsen & Reenberg, 2010). From a regional perspective, West Africa has undergone warming in recent decades and depletion of groundwater, and climate projections include increases in dry spell length and intensification of extreme events (Sylla et al., 2016), which will exacerbate climate-related risks.

Within the WASH sector, assessing climate-related risks has focused on impacts to infrastructure and technical adaptations, often overlooking the social implications (Oates et al., 2014). However, the ways that climate change exacerbates risks to

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household water security, will vary for different individuals and segments of society. Going beyond access to improved water sources, the concept of household water security provides a broader picture of the way water contributes to health and well-being, and its social, cultural and ecological drivers (Wutich et al., 2017). Identifying differential vulnerabilities of social groups is critical to formulate inclusive policies and target resources in the face of climate change. In particular, many groups of women face greater impacts of poor water and sanitation conditions due to a range of biological, social, gendered, and economic factors. These impacts are likely to be increased in the context of changing climate conditions.

The aim of this study was to understand how women's vulnerabilities to climate-related risks to household water security are produced, including coping and adaptive strategies in Centre-East region, Burkina Faso. We then looked at how these vulnerabilities varied among women. The focus on women located in a rural and low-resource setting in Centre-East, Burkina Faso contributes to knowledge on climate risks and adaptation in Africa, which is projected to experience diverse and severe impacts of climate change (Adenle et al., 2017).

2. Inequalities in household water security

Although there are different perspectives on how to define water security, many understandings are multi-dimensional and attempt to integrate several conceptual domains, such as meeting human needs while sustaining ecosystem functions or describing human vulnerability to hazards (Cook & Bakker, 2012). A frequently used definition is the 'availability of an acceptable quantity and quality of water for health, livelihoods, ecosystems and production, coupled with an acceptable level of water-related risks to people, environments, and economies' (Grey & Sadoff, 2007).

Although water security research has been dominated by work addressing water-society challenges at a large-scale, such as country or basin scale, a growing body of research is examining water security at a household and individual level (Bisung & Elliott, 2018; Collins et al., 2019; Cooper-Vince et al., 2018; Jepson et al., 2017; Stevenson et al., 2012). Several studies have reported intra-household variations in water security by gender (Maxfield, 2020; Wutich, 2009). This growing scholarship on household water security is critical to understand the needs of the most marginalized, which are not likely to be captured by water security analyses at other levels due to data aggregation at the national or subnational level (Zeitoun et al., 2016).

At a household level, water security refers to being able to access and benefit from water that is adequate, safe, accessible and affordable for all household uses in order to promote health and wellbeing (Jepson et al., 2017). Water insecurity occurs when one or more of these dimensions is threatened. This understanding of household water security moves beyond seeing water as solely a 'technical' problem, which has been a common lens used by policy makers and practitioners (Lahiri-Dutt, 2015). For instance, tracking progress in the WASH sector, including monitoring of SDG targets 6.1 and 6.2 by the WHO/UNICEF Joint Monitoring Programme, is currently focused on access to infrastructure, such as drinking water supply and sanitation services. For understanding household water security, this information provides a simplified view, that overlooks the role of social, cultural, ecological dynamics (Gimelli et al., 2018; Wutich et al., 2017). In addition, household water security moves beyond a focus only on WASH services for public health outcomes, instead focusing on the broader concept of wellbeing, which includes dimensions such as health and livelihoods (Gimelli et al., 2018).

Although interventions designed to improve household water security are assumed to benefit residents equally, differential and unequal outcomes in areas where access to services has improved have been noted in a number of cases. This may result from a range of social, economic or institutional barriers (Cole et al., 2017; Nicol et al., 2018), such as where poor households remain locked into poor quality and inconvenient services (Carrard et al., 2019). Van Houweling et al. (2017) report that in rural Mozambique the provision of handpumps reinforced existing differences in political affiliation in communities, reinforcing social divides. Following a piped rural water supply intervention in North-East Brazil, some households continued collecting and using water from fecally contaminated sources including public taps and rainwater reservoirs due to non-acceptability of chlorinated water and preference for existing sources (Aleixo et al., 2019). Funder et al. (2012) describe an intervention in Zambia that targeted the poorest households as beneficiaries, but whose access to the contested borehole was continuously overridden due to community decision-making processes dominated by more wealthy residents.

The majority of household water security research has applied what Jepson et al. (2017) describe as a 'humanitarian' lens, which focuses on meeting immediate human needs, such as achieving the SDG targets for universal access. In light of climate change, there is a need for research that conceptualizes household water security in the context of risks and changing conditions. Bradley and Bartram (2013) argue that household water security must incorporate the reciprocal concepts of provision and risk to understand water challenges in their larger social-ecological context. This requires not only focusing on static assessments but considering how climate-related hazards such as changes in temperature, and frequency, intensity and duration of rainfall have important implications for water security (Carrard & Willetts, 2017). Adenle et al. (2017) report stakeholder views that the main challenges facing Africa, especially in rural regions, are due to climate variability, and responses should go beyond climate change to encompass climate variability, disaster risk reduction and broader development challenges.

3. Examining women's vulnerabilities and adaptive capacity

The concept of vulnerability is widely used within environmental change research to mean the propensity to be adversely impacted, and has evolved from several strands of research (Adger, 2006). Vulnerability research focuses on identifying and understanding factors that put people and places at risk and reduce capacity to respond, however; two distinct framings of vulnerability have emerged (Ford et al., 2018). Hazard and

disaster risk reduction studies use vulnerability as part of a 'risk-hazard' model to assess the potential for loss associated with a hazard or threat, often emphasizing socio-economic impacts and technical solutions (Burton, 1993). In the context of water security, this may involve ensuring specific water and sanitation technology choices are suitable under climate uncertainty (e.g. a range of rainfall conditions) (Calow et al., 2011). Vulnerability frameworks originating in development studies and food security research examine structural deficits related to social, economic, cultural, political, and institutional conditions and underlying processes to investigate how certain populations are more negatively affected (Adger, 2006; Wisner et al., 2004). Applying this framing to water security, vulnerability results from a 'lack of entitlements' to sufficient water to ensure wellbeing and derive desired capabilities (Mehta, 2014). These are linked to one's social positionality in a particular context, and are negotiated and produced through power relations, such as discriminatory social norms. In addition to these two lenses, more integrated frameworks have also been proposed, viewing vulnerability as a product of biophysical and social dynamics, and examining their interactions.

Compared to other sectors, there has been limited application of vulnerability to questions of household water security due to a focus on infrastructure access. A review by Kohlitz et al., (2017) describes limited conceptual awareness of structural and relational drivers of vulnerability within work in the WASH sector on climate change risks, and suggest that operationalization of these concepts could provide a better understanding of how climate change will affect achievement of human rights to water and sanitation. This study contributes addressing these limitations, conceptualizing vulnerability as a lack of entitlements to household water security focusing on dimensions of adequate water availability, quality, accessibility, and affordability (Jepson et al., 2017b; Mehta, 2014; Neves-Silva and Heller, 2016). In our study, we also took sanitation into consideration, as it is closely interlinked with water safety and hygiene (Bradley and Bartram, 2013). Vulnerability is examined in the context of a risk framing, where risks are produced by interactions between exposure to hazards, such as extended dry spells, and vulnerabilities, which can be reduced with adaptive capacity.

Due to strongly gendered norms and practices linked to water at the household level, we focus on women's vulnerability and adaptative capacity in the face of climate change (Das, 2017). Pathways which mediate disproportionate impacts for many groups of women include division of labour, as well as biological requirements for safe water, such as for menstrual hygiene. Although we focus on gender norms and relations, these interact with other social and economic factors, which can also drive women's vulnerabilities. The study was conducted involving women living in a remote rural region, where construction of boreholes has taken place over the last 10–20 years. It is important to note that vulnerability approaches do not a priori have a negative focus but aim to uncover the social and ecological processes shaping risk (Ford et al., 2018).

Climate change not only exacerbates risks to water security, but also differential capacities to cope and adapt (Sultana, 2018). Understanding these disparities is needed to identify inclusive ways to increase adaptive capacity in the WASH sector, which has focused on climate-resilient infrastructure, which alone will not be enough to deal with complex changes and uncertainties (Scott et al., 2013). Coping refers to more short-term changes aimed at reduction in losses, and has been explored in a water context in a number of studies (Abubakar, 2018; Adeniji-Oloukoi et al., 2013; Lee et al., 2020; Majuru et al., 2016). In contrast, adaptive capacity refers to the conditions that enable people to anticipate and respond to change, minimizing impacts and taking advantage of new opportunities to re-organize social-ecological systems. In a WASH context, Kohlitz et al. (2019) divide capacity to respond to climate change into specific capacity, referring to response to specific hazards such as a flood or longer dry spell, as well as general capacity to respond to uncertainty and disturbances more broadly.

4. Methods

4.1. Case study site

Burkina Faso, located in West Africa, is a low-income country ranked 142 (of 151) on the Inequality-adjusted Human Development Index. The country is also ranked 145 (of 160) on the Gender Inequality Index and 91 (of 115) on the Gender Development Index (UNDP, 2018). In 2015, only around 54% of the population had access to basic drinking water services and 23% had access to basic sanitation services. However, only 43% of the population in rural areas had access to basic drinking water services, compared to 79% in urban areas. Those with access to basic sanitation services were 12% in rural and 48% in urban areas (WHO/UNICEF JMP, 2017). Burkina Faso experiences a single rainy season with strong seasonality (between May and October) and there are significant water scarcity challenges during dry periods. In many parts of the country, small reservoirs have been built to cope with water shortage challenges. Considerable fluctuations in rainfall occur within seasons and between years, as well as multi-year droughts or wetter periods (Roncoli et al., 2009).

This study was conducted in the Nouaho sub-basin, in the larger Nakanbé basin, shared between Ghana and Burkina Faso (Figure 1). The Nouaho sub-basin is situated in the Centre-East region, with capital Tenkodogo, and is characterized by a Sudano-Sahelian climate (Ibrahim et al., 2012). In addition to dry conditions, this region is exposed to frequent extreme events, such as flooding and drought (Dovie & Kasei, 2018). This case study focuses on rural communities in the sub-basin, where livelihoods depend largely on agriculture and livestock production, with some contribution from off-farm income. There are two main ethnic groups represented, the Mossi, who identify as agriculturalists, but with increasing involvement in livestock production due to climate risks, and the Peul who identify as pastoralists but increasingly grow crops due to rainfall changes, more sedentary lifestyles, and agricultural expansion in grazing areas (Roncoli et al., 2009).

In Burkina Faso, 2030 national plans for water and sanitation apply a human rights framing, while delivery of water and sanitation services is the responsibility of local authorities

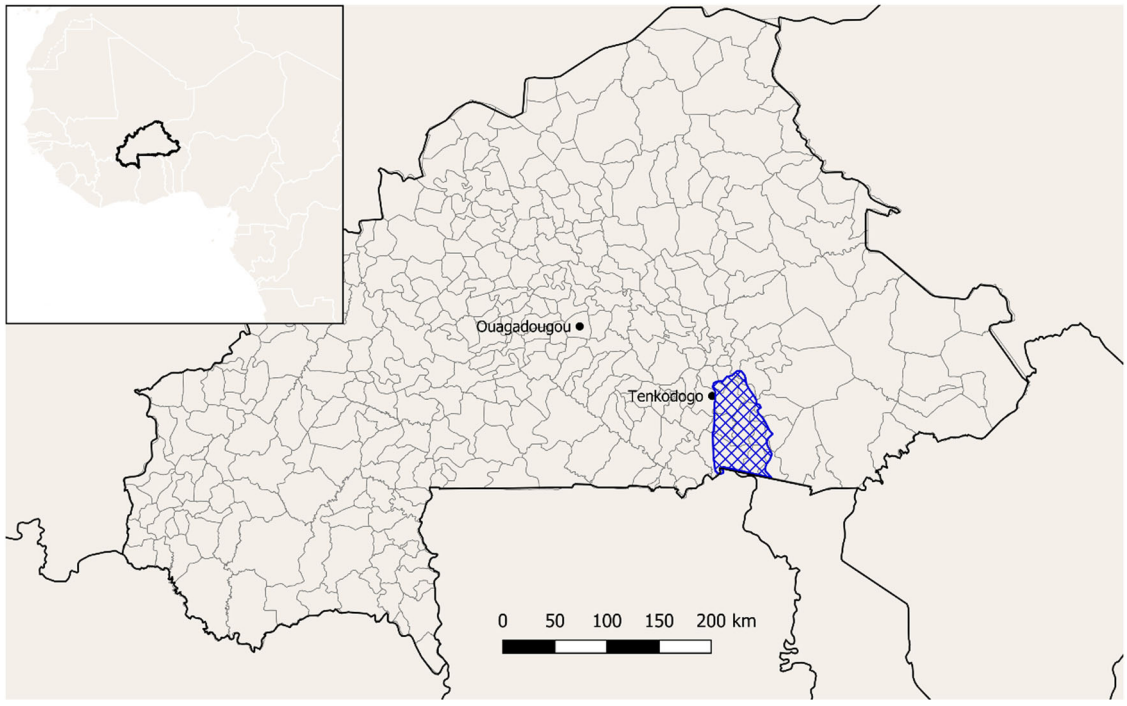

Figure 1. Map of the Nouaho sub-basin (in blue outline).

known as 'communes'. Regions in Burkina Faso are comprised of provinces, which are then comprised of communes. This study focuses on the Nouaho sub-basin because it is the focus of a novel intervention led by WaterAid, a WASH NGO, to improve adaptive capacities to address water security in the face of climate hazards. This intervention involved development of community disaster-risk plans to prepare for flooding and drought events, infrastructure upgrades, and community monitoring of rainfall and boreholes to better manage shared water resources during periods of scarcity in a small number of selected villages. This study was conducted independently from the intervention but with field support from WaterAid, and findings from this study provide additional information to ensure future such interventions in Burkina Faso and other countries in West Africa address differentiated vulnerabilities and contribute to inclusive and sustainable water security.

4.2. Data collection and sampling

Data collection involved focus group discussions and a household survey in the Nouaho sub-basin. Data collection was conducted following ethics approval from Stockholm Environment Institute and in accordance with Swedish legislation on research involving human participants. Informed consent was obtained from all participants in the research, and written notes and audio-recordings of focus groups were taken with permission of respondents.

Twelve focus group discussions were conducted with separate groups of 15–20 women and men in each group to capture gender dimensions. Focus groups were held in community meeting areas in six villages within the upper Nouaho sub-basin, and comprised a wide range of ages, and members of Mossi and Peul ethnicity. These communities were selected where existing contacts were established with the village leaders, who are generally men, and with local organizations working with WaterAid. As village leaders assisted in recruiting participants who were interested in the topic, this may have influenced the composition of the groups. Focus groups were recorded using a digital voice recorder, however detailed note taking was also carried out as the discussions took place outside where it was difficult to record all responses. Focus groups were conducted by the first author and two research assistants who carried out simultaneous translation and note-taking. The research assistants who participated in the focus groups transcribed recordings and detailed notes.

The findings from the focus groups were used to inform the development of a household survey to examine differential vulnerabilities and coping and adaptive capacities within the entire Nouaho sub-basin study site. The survey included questions on climate-related hazards, water security dimensions, such as perceived availability, safety, accessibility and affordability, and coping or adaptive capacity. The importance of water security for productive purposes in the household, in addition to domestic uses, emerged during focus groups and was included in the household survey (e.g. production of food items, livestock watering). A survey of 450 randomly selected respondents was then conducted, using a probability proportional to size 2-stage approach, resulting in 417 completed surveys (N=192 women and 225 men). Within villages a random path method was used, and surveyors targeted a female household representative, or a male representative if unavailable or not permitted to respond. The survey was conducted at the end of the dry season, before agricultural activities began.

4.3. Data analysis

Thematic analysis was conducted by the first author, with feedback from the other authors. The analysis process involved inductive and deductive analysis to interpret the data (Fereday & Muir-Cochrane, 2006), using 'careful reading and re-reading of the data' (Rice & Ezzy, 1999, p. 258). The vulnerability framework was used as a guide to deductively code the findings, examining dimensions of water security in relation to exposure to hazards, vulnerability and adaptive capacity. Microsoft Excel was used for data management and organization. To analyse survey data, descriptive statistics were generated using SAS university edition. This included using means to assess continuous variables and frequencies and percentages to assess categorical variables. Survey responses were compared using a chi-square test, with a *P*-value of 0.05 used as a cut-off between significant and non-significant differences.

5. Results

Respondents in the Nouaho sub-basin reported exposure to both periodic extreme events, such as droughts and floods, as well as water scarcity during the annual dry season, that contributed to risks to household water security. Water was described as inadequate every year between November and June, and respondents perceived lower water availability during the dry season compared with 10–20 years ago due to changes in climate, migrants to the area, growing populations, and increased numbers of animals, as described by two respondents:

> 25 years ago, there was lots of surface water and it would last until the next season. Because the rains were better and there were fewer people and fewer animals using the water points. From 15 years ago until today, the surface water dries up 1–2 months after the last rains, because the population and the number of animals has doubled, and the rains aren't as good as before ; (Male respondent)

'*The temperature has increased, the ground is dry, and when we dig a well, water access isn't simple* (Female respondent).' The region also experiences periodic extreme events, a major drought occurred in 2015 when respondents reported inadequate water even for consumption. A flood in 2016 damaged houses, latrines, and made accessing water points more difficult despite the increased availability of water. We discuss the combined results from the focus group discussions and survey in terms of dimensions of water security, beginning with limited water availability which emerged as the main theme in the findings, followed by water quality, affordability, and concluding with findings on adaptive capacity.

5.1. Gendered vulnerabilities are linked to limited water availability

Women's vulnerabilities to an increasingly inadequate supply of water for household use during the dry season are related to socio-cultural norms around division of labour, and particularly water collection. According to the survey respondents, water collection work for household use was carried out largely by adult women (92%), and girls less than 15 years (23%) in the study site. Men (4%) and boys (3%) also participated in water collection for household use to a much lesser degree (some respondents reported multiple people in the household were responsible for this work). Inadequate quantities of water for domestic use, such as drinking, cooking, hygiene, and cleaning purposes resulted in long wait times at improved water sources (boreholes with hand pumps) and use of dug wells with poorer quality as secondary sources in some cases. The median travel and wait time for collecting water supplies for domestic uses from boreholes was approximately 36 minutes during the rainy season, and 70 minutes during the dry season. For dug wells it was 17 minutes and 36 minutes, respectively. A female respondent explained, '*We need more boreholes to resolve the problem of inadequate water supply, because often we don't even have water for showering, and even doing the dishes or laundry, even the dug well dries up from time to time.*' Long lines also occurred during very hot weather, and during celebrations or funerals when more water is needed. In focus groups, women reported that men were aware of increased time required to access water during certain periods, and despite their wish for assistance with the heavy load of water collection work, gender norms meant that most men do not participate in water collection for household use. However, some women reported negotiating with their husbands to get assistance with water collection, or using water men had collected for animals.

A contributing factor was that water collection for domestic use was intertwined with other water-related work such as watering livestock, as this involved sharing the same water points for all uses during the dry season, when water availability is lowest. During the rainy season, livestock were watered by men using surface water (76%), with the remainder watered using boreholes and dug-wells. In the dry season, the opposite was the case, when boreholes (78%) and dug wells (12%) were used, with little use of surface water (7%). The use of water points was negotiated for household and livestock with allocations of times of day, however, men were reported to have greater control over these arrangements, '*men don't wait for water*,' as one female respondent explained.

Within and across households, social relations were strained by limited opportunity to secure adequate water. Conflicts occurred between women at water points, such as when a woman had a large number of containers or wanted to go ahead in line. Conflicts over water were reported with other households (women = 43% and men = 36%) and between household members (women = 17% and men = 14%). In addition, some respondents reported that inadequate amounts of water were available for hygiene practices and showers, a greater concern for women respondents (women = 21% and men = 13%, $\chi 2 = 5.46$; $P = 0.019$). Both men (40%) and women (50%) reported often feeling worry over inadequate water supply for drinking and household use, although this was greater for women ($\chi 2 = 4.4$; $P = 0.036$). A greater proportion of women (22%) surveyed compared to men (7.5%) reported that because of water-related work they did not have time for other important things ($\chi 2 = 18.5$; $P < 0.001$).

Vulnerability differed among groups of women related to the range of water-related tasks, as overall 19% of women collected water for both domestic use and livestock, and in 11% of the households women were responsible for collection of water

for domestic use, livestock, and small businesses. In particular, many women from the Mossi ethnic group required water for domestic uses, small livestock (e.g. goats), and for income-generating activities (e.g. shea butter production, food and drink production). In focus groups Mossi women reported that inadequate water availability during the dry season hindered their income-generating activities, and they were over-burdened with water-related work, as well as other unpaid work, while in contrast Peul women did not collect water for productive purposes, and were satisfied with the division of labour.

5.2. Women's vulnerability to unsafe water and sanitation varies with social factors

Some residents were unable to access safe water sources, and risks of using unsafe water will be exacerbated by climate change as exposure to pathogens in unsafe water sources increases during including higher temperatures or flood events (Howard et al., 2016). This was varied among women due to social factors, and we report differences due to ethnicity and education.

Overall, boreholes were used for drinking by most respondents (between 85% and 86% year-round), which would be considered a safe ('improved') source for drinking water, while 10% of respondents used an unprotected well for drinking. However, 12% used an unprotected well for domestic uses during the dry season (e.g. laundry, hygiene) indicating some respondents used a borehole for drinking water and an unprotected well for other domestic water uses (Table 1). Despite an improved primary water source some respondents in focus groups reported using less acceptable sources, such as unprotected wells when there was insufficient water at boreholes, too many users, break-downs, or inaccessibility, as one female respondent explained '*There was a problem with water, because the borehole was broken for 4 months, and during this time we drank water from the wells with the animals. Also, after the repairs there is still not enough water in the borehole.*'

Poor sanitation was prevalent in the sub-basin, with a high level of open defecation (66%). Of households with toilets, no water (72%) or soap (88%) for handwashing was observed nearby. Flooding may increase contamination in areas without sanitation facilities or where sanitation facilities are damaged, '*The water destroyed our fields, our houses fell down, and we had to look for the means to reconstruct*' (Female respondent). Due to biological factors and social norms, women and girls face disproportionate impacts of poor sanitation and hygiene, such as urogenital infections and risks of violence (Caruso et al., 2017; Dickin et al., 2018).

Being able to use safe water sources differed among women according to ethnicity and education status. Use of unsafe sources for drinking was higher among women with little educational attainment, as a larger proportion of women with some educational attainment (literacy or schooling) used a borehole or public tap rather than an unprotected well (100% compared with 88% respectively, $\chi 2 = 15.75$; $P = 0.001$). Similar to water source, a greater proportion of women with little education used traditional latrines or practiced open defecation, rather than improved toilets (e.g. ventilated improved pit latrine), although the difference was not significant (85% compared to 73% of women with educational attainment). Vulnerability to poor quality water was greater for Peul women than Mossi women, as many Peul households were located further away from boreholes, and thus women collected water from surface water or used dug wells during the rainy season, only using the more inaccessible boreholes when these sources dried. In some locations, a complete lack of boreholes meant they used dug wells or surface water year-round. Due to cultural practices, Peul households also move to locations with better water availability for livestock, which may result in improved sources being inaccessible. Because of this, Peul women faced greater vulnerabilities related to unsafe water compared with Mossi women.

5.3. Borehole break-downs and intra-household negotiation impacts affordability

Fees for water were paid to water user associations (community associations set up to manage boreholes, such as ensuring maintenance, protecting the water point from contamination, and interacting with local authorities) and were similar across the sub-basin. Fees were paid annually to community water user associations, with a fee ranging from, 500–1000 CFA (1 -2 USD) for women and 1000–2000 CFA (2-4 USD) for men, as well as fees for children and animals in some cases, although 3% of respondents paid per container instead. These fees covered borehole repair, however; in the case of frequent borehole breakdowns these fees were not enough to cover repairs, requiring assistance from local authorities.

Spending was negotiated within households, with women having less control over spending decisions compared to men, producing increased vulnerability in the face of frequent break-downs. Men were viewed as responsible for paying household water costs for family members by 59% of respondents, because of a religious obligation, social norms as head of household, or because women had no income, while women were responsible for collecting water. A respondent explained, '*I have to help with this, as women already deal with the transport of water.*' (Male respondent). These gendered responsibilities did not always play out in the same way, '*Each woman finds the money for her fees and pays, the head of household can't manage this because it's too much, we are three (wives)*' (Female respondent). Some reasons included that the male head of household did not concern himself with water issues due to viewing this as a women's issue, had migrated, or had no money, '*It turned out the man didn't have anything*

Table 1. Water source reported by male and female respondents divided by season and type of use ($N = 417$).

	Dry season		Wet season	
	Drinking	Other domestic uses	Drinking	Other domestic uses
Borehole	360	353	353	340
Unprotected well	43	48	40	43
Protected well	3	5	3	5
Surface water	0	1	4	3
Village tap	11	10	11	10
Rainwater harvesting	0	0	5	16

so the wives sold some chickens in order to pay' (Female respondent).

Over-pumping was reported to occur during the dry season when there is limited water, often bringing up muddy water. In one village respondents reported that break-downs occurred all the time due to over-pumping. More frequent break-downs at water points threaten affordability as repairs were described as expensive and fees could be difficult to collect.

5.4. Differentiated capacities to cope and adapt

Challenges that many women faced related to inadequate water availability were the most apparent manifestation of vulnerabilities at the gender-climate-water nexus. Due to gender roles that assigned household water collection and management work to women, women focus group respondents reported using coping strategies such as getting up very early, making water reserves within the household, prioritizing water for drinking and cooking, being careful with water use, increasing time required for water collection, reusing dishwater for animals, or only doing children's laundry. Many coping strategies are used in the short-term but will not address risks to water security over a longer period, and may contribute to 'erosive' coping in some cases. For instance, stopping economic activities and reducing livestock production were reported as strategies to deal with changes in water resources (Table 2).

As women manage water in the household, they have some power in determining uses within households, and a larger proportion of women made decisions on household use of water compared to men (77%), or decisions were taken as a couple (19%). For example, women reported instructing children not to play with or waste water. However, in focus groups women reported conflicts or instances of domestic violence that had arisen due to intra-household water use, such as male household members not having water available for showers or purposefully wasting water. Very few specific adaptive capacities were reported related to limited quantities of water for household use, respondents instead listed a number of common agricultural adaptations instead (e.g. stone bunds, compost pits). Respondents in one village which received the WaterAid intervention described how they monitor rainfall to determine how intensively borehole water can be used the following dry season. Responsibility for responding to water problems was seen as the role of community water associations, which can include borehole management committees (*comités de gestion*) or village water user associations (*associations des usagers de l'eau*) that oversee all boreholes in the village, however, women were rarely involved in decision-making roles in these groups. For example, women members of such groups had a role of ensuring good hygiene conditions of the borehole. In focus groups, women reported that women would get into conflicts with each other if they were involved in managing the water point, and that they had limited literacy and skills to communicate with decision-makers about these issues compared with men. They explained that culturally 'men are in front' and 'women listen to men' and thus they relied on men for water point management (e.g. ensuring repairs). However, a majority of male (75%) and female (73%) respondents indicated their household had no or limited influence in decisions of local authorities to resolve water-related problems, indicating limited accountability and participation opportunities to voice concerns to services providers. Despite village water user associations that are designed to collaborate with local authorities, this indicates limited empowerment of users to address emerging or existing conditions that produce risks to water security.

Levels of more general adaptive capacity, such as social capital, access to resources, flexibility, and agency, also differed due to gender and other social factors. Some men and women were members community associations (men = 42% and women = 29%), which may contribute to social capital, sharing of knowledge and opportunities for collective action. Many women had limited agency with respect to household decisions related to control over income and assets (e.g. bicycles, motorbikes), which could influence investment or mobility to access water or sanitation services. For example, the decision to pay for a major health expenditure was largely taken by male heads of household (78%) or by the couple (19%), despite entrenched gender roles that results in many women acting as carers for sick family members (Sweetman & Medland, 2017). These differences in agency in household and community decision-making and control over assets can play an important role in making choices and investments to adapt to water security risks, and adaptation planning requires explicit consideration of constraints facing certain groups. Community resources are other types of assets that some residents have access to. However respondents mainly relied on family and friends in their village (men = 89% and women = 93%) or in another village (men = 57% and women = 40%) to deal with water-related hazards, while reliance on organizations such as NGOs (men =

Table 2. Strategies reported by women respondents to deal with changes to water resources that have occurred in the past 10 years (*N* female respondents is 192).

	% Women respondents
Stopping an economic activity	12.4
Abandoning vegetable growing	9.1
Increasing number of boreholes available	2.2
Paying more for access to water	5.3
Digging new wells	6.4
Starting an economic activity	5.5
Reducing frequency of hygiene activities (e.g. showers)	10.0
Prioritizing water for drinking and cooking	22.4
Reduced livestock production	22.6
Increased time for water collection	15.1

Table 3. Description of non-agricultural income-generating activities conducted by women described by respondents (*N* = 417).

Type of activity	*N*	%
No activity	214	51.32
Sale of food items	70	16.79
Sale of sauce	34	8.16
Sale of local beer	29	6.95
Buying/sale of cereals	27	6.47
Garden vegetables	18	4.32
Sale of wood	3	0.72
Clothing sale	2	0.48
Livestock raising	2	0.48
Shea butter production	2	0.48
Sale of juice	1	0.24
Sale of milk	1	0.24
Other	14	3.36

3% and women = 1%), local authorities (men = 16% and women = 10%), or health centres (men = 3% and women = 0%) was limited.

Despite limited say in the use of household income obtained from agricultural activities, a larger proportion of women (49%), than men (27%) conducted off-farm income-generating activities, generally using the same boreholes used for domestic purposes for many of these activities (Table 3). This can provide assets as well as flexibility to adapt during periods of environmental shocks with impacts on livelihoods, e.g. poor harvests. For example, one woman reported, '*It's with my Shea butter production that I help my husband with some expenses … Due to the little amount of water we always try to make reserves to avoid a long queue.*' As fewer men are involved in these activities, they have less opportunities for off-farm work, and must use other strategies, often migration to surrounding regions and countries to find income-generating opportunities. However, many women in the sub-basin do not conduct any off-farm income-generating activities (51%), and this group, particularly in the Peul ethnic group, may have fewer income sources and assets available to adapt. While some Peul women sell milk, this was limited when there was inadequate water for cattle.

In the Nouaho sub-basin, few respondents had formal education. However, listening to the radio at least one a week was a common practice among both men (67%) and women (56%), indicating a possible way to disseminate information related to adaptation planning, especially given the inaccessibility of many villages during the rainy season. As women have higher illiteracy (85% compared to 75% among men) and listen to the radio less often compared with men respondents, interventions disseminating information require attention to these disparities.

6. Discussion

This study focused on understanding how women's vulnerabilities and responses to climate-related risks to household water security are produced in the Nouaho sub-basin. The findings illustrate how vulnerabilities arise due to gender dynamics as well as other social and economic factors. These factors mediated respondents' ability to secure adequate water resources, and climate variability and change is expected to exacerbate these conditions in West Africa, particularly dry spell length and intensification of extreme events such as droughts (Howard et al., 2016; Sylla et al., 2016). The study also shows the need to consider household water security in the context of socio-ecological dynamics, as water conditions differed greatly by season.

Women experienced disproportionate vulnerabilities related to limited water availability during the dry season. This occurred due to gender roles and norms that govern the division of labour and how men and women participate in water-related decision-making, as men were able to secure water for livestock when needed, however, women struggled to obtain enough for water for domestic as well as productive tasks during the dry season when boreholes were shared. Women who desired assistance with water collection were not able to obtain this from men in their households due to gender norms. However, as gender relations are dynamic rather than static, the need to adapt to changing climate conditions may provide entry points that contribute to addressing gender norms and practices relating to water that reinforce inequalities. In the North Eastern Hill region in India, men increasingly participated in water-related activities due to limited water availability, such as collecting water at dug-out water holes at night when they were recharged, or participating in collection from water storage tanks with strict opening hours (Singh & Singh, 2015). Thus, adaptation planning by WASH actors has potential to contribute to addressing negative gender norms that constrain opportunities for both men and women.

Limitations to securing enough water was the main concern for respondents, however, the question of affordability also emerged. Households paid fees to support maintenance and repair of boreholes, however, these fees were actually divided into separate costs for women, men, children and animals. In some households women were responsible for paying all of these fees for the household, while in others men were viewed as responsible, and these households relations impact affordability. While the fees are used to cover repairs, climate change creates risks for further break-downs and these repairs may become more unaffordable. Bonsor et al., 2011 report that the main climate risk for boreholes is longer dry seasons and more intense rainfall, as high demand can lead to mechanical failure, or contamination due to heavy rainfall. Residents rely on the local authorities for new boreholes and for repairs they cannot carry out, however local authorities also have limited resources. Although this study focused on water security risks at a household level, this finding highlights the role of local authorities is critical in ensuring and 'co-producing' inclusive services, and could be explored further in the context of climate change adaptation to water security risks.

Findings in this study indicate the need for further exploration of the role of intersecting inequalities in the context of climate change adaptation and household water security, as women or men are not homogenous groups, and face differing levels of water security due to interactions with other dimensions of exclusion, e.g. poverty, ethnicity, and education level. We found participation in income-generating activities was higher among Mossi women, which may provide more flexibility and greater opportunities to adapt to certain water security risks. These activities are linked to a larger work burden compared with Peul women, who were satisfied with arrangement of carrying out domestic tasks, but who deal with poorer water quality in the study site. This highlights the different ways that people value water, and ways that climate-related risks to household water security threaten human wellbeing beyond public health (Mehta, 2014).

6.1. Lessons for adaptation in the WASH sector

While there are limited examples of non-technical climate adaptation in the WASH sector, adaptation research more generally has identified several areas that contribute to adaptive capacity that could be explored by the WASH sector to target differentiated vulnerabilities (Cinner et al., 2018). This is important to explore, as adaptation activities described by

respondents in this study were those related to agriculture rather than water collection and management.

Sharing information and learning play an important role in the WASH sector, and have potential to increase knowledge of water-hazards and adaptation options. These activities have been conducted on a small-scale in the WaterAid intervention in the sub-basin, however, there is potential for scaling-up of capacity building programmes. For instance, to reach residents across a large area in Sofala province Mozambique, radio programmes were produced on water and sanitation topics, which included official alerts and health messages during floods to reduce waterborne disease outbreaks (Fogde et al., 2013). As we found that a greater proportion of women with lower education level used unsafe water and sanitation, the needs of marginalized groups must be explicitly considered in any adaptation actions (Shackleton et al., 2015). Non-traditional learning approaches could be developed, such as peer to peer networks between communities to share learning from interventions carried out in certain villages. In the study site, these types of activities could also increase capacity to act collectively which was found to be limited, thus strengthening connections between communities, local NGOs and WASH authorities.

Adaptation planning can also contribute to women's empowerment in the WASH sector, such as increasing agency and voice of those marginalized in decision-making at household and community levels, to respond to change and shape their future. However addressing this is challenging in contexts with negative stereotypes around female leadership, a view that was held by both men and women in the study site. In community adaptation interventions that do not take these power relations into account, women may be marginalized or not given opportunity to contribute input and highlight concerns (Sultana, 2018). Entry points to tackle these norms, such as women leaders as role models, and women's membership of social and economic groups have been identified in other contexts and could be tested (Mandara et al., 2017).

7. Conclusion

Climate change and variability threatens household water security, however there are differential vulnerabilities for individuals and communities. This study showed that gender norms and division of labour related to water collection and management produced vulnerabilities for women related to increasingly limited water availability during the dry season. Vulnerabilities also differed among women, as women from the Mossi ethnic group used water for domestic as well as productive activities, with inadequate water exacerbating their work burden and limiting economic opportunities, while Peul women used of water for domestic tasks, often of poorer quality due to their more remote locations far from water points. This emphasizes the importance of a broader understanding of the different ways that people value and use water in the context of dynamic social-ecological conditions.

With increasing attention to the development of climate resilient WASH services by practitioners and policy makers, this study shows the need for consideration of how discriminatory norms and gender dynamics that create inequalities, such as women's burden of unpaid work and limited participation opportunities in community decisions, must be considered in adaptation activities taken in the WASH sector. In the face of climate change, this is critical to avoid technical approaches blind to gender or other social differences that emphasize service delivery but ignore or even reinforce inequalities (Cleaver & Hamada, 2010; Gonda, 2016).

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